

AMENDMENTS TO THE CLAIMS

1. (currently amended) A battery charging apparatus which charges a ~~second~~ battery, comprising:

a voltage detecting circuit arranged and configured to detect ~~for detecting~~ a battery voltage of said ~~second~~ battery and for outputting a signal in response to a ~~said~~ detected battery voltage;

a current detecting circuit arranged and configured to detect ~~for detecting~~ a ~~battery~~ charging current supplied to said ~~second~~ battery and for outputting a signal in response to a ~~said~~ detected ~~battery~~ charging current;

a charging circuit arranged and configured to control said charging ~~for controlling~~ a current ~~supply to said second battery to charge said second battery~~ such that said detected battery voltage increases to become detected by said voltage detecting circuit ~~becomes~~ substantially equal to a first pre-set battery voltage in response to a first input control signal ~~applied thereto~~ and also such that ~~[[a]] said detected~~ charging current ~~detected by the current detecting circuit~~ becomes substantially equal to a constant charging current predetermined in response to a second input control signal ~~applied thereto~~; and

a charge control circuit that instructs said charging circuit by ~~sending~~ said first and said second input control signals ~~applied to said charging circuit~~ to set said first pre-set battery voltage and said constant charging current in response to ~~a voltage indicated by said signal outputs from said voltage detecting circuit and said current detecting circuits respectively.~~

2. (currently amended) The battery charging apparatus as defined in Claim 1, wherein the charge control circuit is arranged and configured to instruct ~~instructs~~ the charging circuit to perform ~~[[a]] constant current charging in which a charging is executed~~ to flow a first constant current to the ~~second~~ battery and subsequently ~~another charging is executed~~ to flow a second constant current greater than the first constant current to the ~~second~~ battery when the detected battery voltage of the ~~second~~ battery is smaller than a second pre-set voltage, and to instruct

~~instructs~~ the charging circuit to perform pulse charging, in which flowing current to said ~~second~~ battery and pausing current flow to said ~~second~~ battery are alternately performed at intervals of a pre-determined time period.

3. (currently amended) The battery charging apparatus as defined in Claim 2, wherein the charge control circuit instructs the charging circuit to control the charging current flowing to the ~~second~~ battery such that ~~the battery~~ a charging voltage applied across said battery becomes substantially equal to a third constant voltage during the constant current charging during the pulse charging and also such that the ~~battery~~ charging voltage becomes substantially equal to ~~a~~ the first constant voltage smaller than the third constant voltage during the pausing in the pulse charging.

4. (currently amended) The battery charging apparatus as defined in Claim 3, wherein the charge control circuit instructs the charging circuit to perform the constant current charging to supply the second constant current to the ~~second~~ battery when the battery voltage becomes substantially equal to a third pre-set voltage greater than the second pre-set voltage and also to perform the constant voltage charging to control the charging current such that the charging ~~battery~~ voltage becomes substantially equal to the third constant voltage when the battery voltage becomes substantially equal to a fourth pre-set voltage greater than the third pre-set voltage.

5. (currently amended) The battery charging apparatus as defined in Claim 3, wherein the charge control circuit instructs the charging circuit to control the charging current flowing through the ~~second~~ battery such that the charging ~~battery~~ voltage becomes substantially equal to the third constant voltage during the constant current charging before the pulse charging is executed.

6. (currently amended) The battery charging apparatus as defined in Claim 3, wherein the charge control circuit instructs the charging circuit to control the charging current flowing through the ~~second~~ battery such that the charging ~~battery~~ voltage becomes substantially equal to the first constant voltage when the battery voltage is smaller than the first pre-set voltage which is smaller than the second pre-set voltage and also such that the charging ~~battery~~ voltage

becomes substantially equal to the second constant voltage which is less than the third constant voltage and greater than the first constant voltage, during the constant current charging before the pulse charging is executed.

7. (currently amended) The battery charging apparatus as defined in Claim 5, wherein the charging circuit further comprises:

a constant voltage generating circuit that generates said first, ~~second~~, and third constant voltages;

a voltage switching circuit that selects and outputs one of the first and third constant voltages output from the constant voltage generating circuit in accordance with the control signals from the charge control circuit;

a control transistor that outputs a current to the ~~second~~ battery in response to a control signal input to the control transistor thereto; and

a control circuit that controls the control transistor such that the battery voltage represented by a signal output from the voltage detecting circuit becomes substantially equal to a voltage represented by a signal output from the voltage switching circuit and that the charging current represented by a signal output from the current detecting circuit becomes substantially equal to a constant current represented by a signal output from ~~the~~ a signal switching circuit arranged and configured to supply signals to said control circuit.

8. (currently amended) The battery charging apparatus as defined in Claim 6, wherein the charging circuit further comprises:

a constant voltage generating circuit that generates the first, ~~second~~, and third constant voltages;

a voltage switching circuit that selects and outputs one of the first and third constant voltages output from the constant voltage generating circuit in accordance with the control signals from the charge control circuit;

a control transistor that outputs a current to the ~~second~~ battery in response to a control signal input thereto; and

a control circuit that controls the control transistor such that the battery voltage represented by a signal output from the voltage detecting circuit becomes substantially equal to a voltage represented by a signal output from the voltage switching circuit and that the charging current represented by a signal output from the current detecting circuit becomes substantially equal to a constant current represented by a signal ~~output~~ received from ~~a~~ the signal switching circuit.

9. (currently amended) The battery charging apparatus as defined in Claim 2, further comprising a charge-end detecting circuit that determines an event that indicates a charging is completed relative to the ~~second~~ battery and outputs a predetermined signal when the charging current detected by the current detecting circuit becomes lower than the first constant current, and wherein the charge control circuit causes the charging circuit to stop the charging upon receiving the signal indicative of a charge end output from the charge-end detecting circuit.

10. (currently amended) The battery charging apparatus as defined in Claim 3, wherein the first constant voltage is a voltage greater than an over discharge voltage of the ~~second~~ battery and the third constant voltage is a voltage substantially equal to a full charge voltage of the ~~second~~ battery.

11. (currently amended) The battery charging apparatus as defined in Claim 7, wherein the current detecting circuit comprises:

a resistor through which the charging charge current to be supplied to the ~~second~~ battery flows; and

a current detector that detects the charging charge current based on a voltage across the resistor and outputs a signal in response to the detected charging charge current,

wherein the voltage detecting circuit, the current detector of the current detecting circuit, the charge control circuit, a charge-end detecting circuit, and several components of the charging circuit including a constant voltage generating circuit, a voltage switching circuit, a constant current reference signal generating circuit, a signal switching circuit, and a control circuit are integrated into a single signal integrated circuit chip.

12. (currently amended) The battery charging apparatus as defined in Claim 8, wherein the current detecting circuit comprises:

a resistor through which the charging charge current to be supplied to the ~~second~~ battery flows; and

a current detector that detects the charging charge current based on a voltage across the resistor and outputs a signal in response to the detected charging charge current,

wherein the voltage detecting circuit, the current detector of the current detecting circuit, the charge control circuit, a charge-end detecting circuit, and several components of the charging circuit including a constant voltage generating circuit, a voltage switching circuit, a constant current reference signal generating circuit, a signal switching circuit, and a control circuit are integrated into a single signal integrated circuit chip.

13. (currently amended) The battery charging apparatus as defined in Claim 1, wherein the ~~second~~ battery is a nonaqueous ~~second~~ battery.

14. (currently amended) The battery charging apparatus as defined in Claim 1, wherein the ~~second~~ battery is a lithium ion battery.

15. (currently amended) A charging method for a ~~second~~ battery, comprising the steps of:

first performing a first constant current charging by supplying a first constant current to the ~~second~~ battery when a battery voltage of the ~~second~~ battery is smaller than a first pre-set voltage;

second performing a second constant current charging by supplying a second constant current greater than the first constant current to the ~~second~~ battery when the battery voltage of the ~~second~~ battery is greater than the first pre-set voltage; and

operating a pulse charging of the battery when the battery voltage of the ~~second~~ battery increases to be ~~becomes~~ equal to or greater than a second pre-set voltage greater than the first pre-set voltage by alternately carrying out, at intervals of a predetermined time period, a constant current charging in which the second constant current is supplied to the ~~second~~ battery and a pausing in which the supply of the constant current charging is stopped.

16. (currently amended) The charging method as defined in Claim 15, wherein the operating step comprises ~~a step of controlling a charging the charge~~ current to the ~~second~~ battery such that ~~the battery a charging~~ voltage of the ~~second~~ battery becomes substantially equal to a third constant voltage during the constant current charging of the pulse charging and such that the ~~battery charging~~ voltage of the ~~second~~ battery becomes substantially equal to a first constant voltage smaller than the third constant voltage during the pausing of the pulse charging.

17. (currently amended) The charging method as defined in Claim 16, further comprising steps of first executing a constant current charging in which the constant current charging with the second constant current is performed to the ~~second~~ battery when the battery voltage of the ~~second~~ battery becomes substantially equal to the third pre-set voltage ~~equal to or~~ greater than the second pre-set voltage and second executing a constant voltage charging in which the charging current is controlled such that the ~~battery charging~~ voltage of the ~~second~~ battery becomes substantially equal to the third constant voltage when the battery voltage of the ~~second~~ battery becomes substantially equal to a fourth pre-set voltage ~~equal to or~~ greater than the third pre-set voltage.

18. (currently amended) The charging method as defined in Claim 16, wherein the charging current to the ~~second~~ battery is controlled such that the charging battery voltage of the ~~second~~ battery becomes substantially equal to the third constant voltage during the first and second constant current charging.

19. (currently amended) The charging method as defined in Claim 16, wherein the charging current to the ~~second~~ battery is controlled such that the charging battery voltage of the ~~second~~ battery becomes substantially equal to the first constant voltage when the battery voltage of the ~~second~~ battery is smaller than the first pre-set voltage during the first constant current charging and such that the charging battery voltage of the ~~second~~ battery becomes substantially equal to a the second constant voltage smaller than the third constant voltage and greater than the first constant voltage during the first constant current charging.

20. (currently amended) The charging method as defined in Claim 15, further comprising steps of determining that the charging is completed when the charging current to the ~~second~~ battery becomes substantially equal to a predetermined current value smaller than the first constant current and subsequently terminating the charging to the ~~second~~ battery.

21. (currently amended) The charging method as defined in Claim 15, wherein the ~~second~~ battery is a nonaqueous ~~second~~ battery.

22. (currently amended) The charging method as defined in Claim 15, wherein the ~~second~~ battery is a lithium ion battery.

23. (new) A battery charging apparatus which charges a battery, comprising:

a voltage detecting circuit arranged and configured to detect a battery voltage of said battery and for outputting a signal in response to a detected battery voltage;

a current detecting circuit arranged and configured to detect a charging current supplied to said battery and for outputting a signal in response to a detected charging current;

a charging circuit arranged and configured to control said charging current such that said detected battery voltage increases to become substantially equal to a first pre-set voltage in

response to an input control signal and also such that said detected charging current becomes substantially equal to a constant current predetermined in response to the input control signal; and

a charge control circuit that instructs said charging circuit by the input control signal to set said first pre-set voltage and said constant current in response to said signal from said voltage detecting circuit.

24. (new) The battery charging apparatus as defined in Claim 23, wherein the charge control circuit is arranged and configured to instruct the charging circuit to perform constant current charging to flow a first constant current to the battery and subsequently to flow a second constant current greater than the first constant current to the battery when the detected battery voltage of the battery is smaller than a second pre-set voltage, and to instruct the charging circuit to perform pulse charging, in which flowing current to said battery and pausing current flow to said battery are alternately performed at intervals of a pre-determined time period.

25. (new) The battery charging apparatus as defined in Claim 24, wherein the charge control circuit instructs the charging circuit to control the charging current flowing to the battery such that a charging voltage applied across said battery becomes substantially equal to a third constant voltage during the constant current charging during the pulse charging and also such that the charging voltage becomes substantially equal to a first constant voltage smaller than the third constant voltage during the pausing in the pulse charging.

26. (new) The battery charging apparatus as defined in Claim 25, wherein the charge control circuit instructs the charging circuit to perform the constant current charging to supply the second constant current to the battery when the battery voltage becomes substantially equal to a third pre-set voltage greater than the second pre-set voltage and also to perform constant voltage charging to control the charging current such that the charging voltage becomes substantially equal to the third constant voltage when the battery voltage becomes substantially equal to a fourth pre-set voltage greater than the third pre-set voltage.

27. (new) The battery charging apparatus as defined in Claim 25, wherein the

charge control circuit instructs the charging circuit to control the charging current flowing through the battery such that the charging voltage becomes substantially equal to the third constant voltage during the constant current charging before the pulse charging is executed.

28. (new) The battery charging apparatus as defined in Claim 25, wherein the charge control circuit instructs the charging circuit to control the charging current flowing through the battery such that the charging voltage becomes substantially equal to the first constant voltage when the battery voltage is smaller than the first pre-set voltage which is smaller than the second pre-set voltage and also such that the charging voltage becomes substantially equal to the second constant voltage which is less than the third constant voltage and greater than the first constant voltage, during the constant current charging before the pulse charging is executed.

29. (new) The battery charging apparatus as defined in Claim 27, wherein the charging circuit further comprises:

a constant voltage generating circuit that generates said first, and third constant voltages;

a voltage switching circuit that selects and outputs one of the first and third constant voltages output from the constant voltage generating circuit in accordance with the control signals from the charge control circuit;

a control transistor that outputs a current to the battery in response to a control signal input to the control transistor; and

a control circuit that controls the control transistor such that the battery voltage represented by a signal output from the voltage detecting circuit becomes substantially equal to a voltage represented by a signal output from the voltage switching circuit and that the charging current represented by a signal output from the current detecting circuit becomes substantially equal to a constant current represented by a signal output from a signal switching circuit arranged and configured to supply signals to said control circuit.

30. (new) The battery charging apparatus as defined in Claim 28, wherein the charging circuit further comprises:

a constant voltage generating circuit that generates the first, and third constant voltages;

a voltage switching circuit that selects and outputs one of the first and third constant voltages output from the constant voltage generating circuit in accordance with the control signals from the charge control circuit;

a control transistor that outputs a current to the battery in response to a control signal input thereto; and

a control circuit that controls the control transistor such that the battery voltage represented by a signal output from the voltage detecting circuit becomes substantially equal to a voltage represented by a signal output from the voltage switching circuit and that the charging current represented by a signal output from the current detecting circuit becomes substantially equal to a constant current represented by a signal received from a signal switching circuit.

31. (new) The battery charging apparatus as defined in Claim 24, further comprising a charge-end detecting circuit that determines an event that indicates a charging is completed relative to the battery and outputs a predetermined signal when the charging current detected by the current detecting circuit becomes lower than the first constant current, and wherein the charge control circuit causes the charging circuit to stop the charging upon receiving the signal indicative of a charge end output from the charge-end detecting circuit.

32. (new) The battery charging apparatus as defined in Claim 25, wherein the first constant voltage is a voltage greater than an over discharge voltage of the battery and the third constant voltage is a voltage substantially equal to a full charge voltage of the battery.

33. (new) The battery charging apparatus as defined in Claim 28, wherein the current detecting circuit comprises:

a resistor through which the charging current to be supplied to the battery flows;
and

a current detector that detects the charging current based on a voltage across the resistor and outputs a signal in response to the detected charging current,

wherein the voltage detecting circuit, the current detector of the current detecting circuit, the charge control circuit, a charge-end detecting circuit, and several components of the charging circuit including a constant voltage generating circuit, a voltage switching circuit, a constant current reference signal generating circuit, a signal switching circuit, and a control circuit are integrated into a single integrated circuit chip.

34. (new) The battery charging apparatus as defined in Claim 30, wherein the current detecting circuit comprises:

a resistor through which the charging current to be supplied to the battery flows;
and

a current detector that detects the charging current based on a voltage across the resistor and outputs a signal in response to the detected charging current,

wherein the voltage detecting circuit, the current detector of the current detecting circuit, the charge control circuit, a charge-end detecting circuit, and several components of the charging circuit including a constant voltage generating circuit, a voltage switching circuit, a constant current reference signal generating circuit, a signal switching circuit, and a control circuit are integrated into a single integrated circuit chip.

35. (new) The battery charging apparatus as defined in Claim 23, wherein the battery is a nonaqueous battery.

36. (new) The battery charging apparatus as defined in Claim 23, wherein the battery is a lithium ion battery.